(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 689 359 A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 95304120.9

(51) Int. Cl.^{6}: H04N 7/50

(22) Date of filing: 14.06.95

(30) Priority: 15.06.94 KR 9413488

(43) Date of publication of application: 27.12.95 Bulletin 95/52

(84) Designated Contracting States: DE FR GB

(71) Applicant: Samsung Electronics Co., Ltd.
416 Maetan-dong
Paldal-gu
Suwon-city, Kyungki-do (KR)

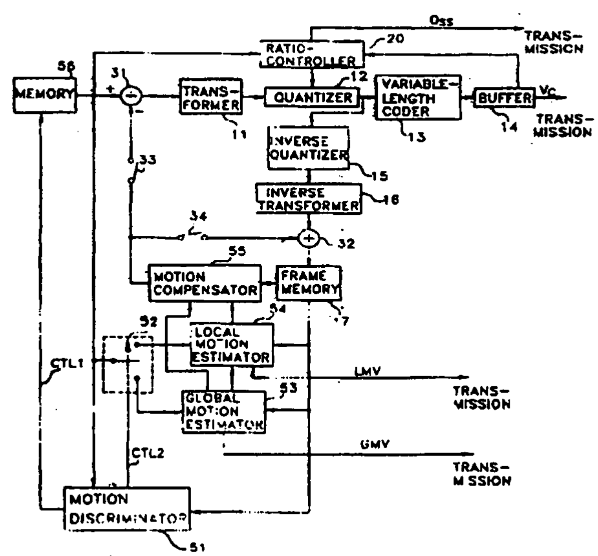
(72) Inventor: Jeong, Jechang
108-1007 Woosung Apt.,
Yanghae-Dong
Seocho-gu, Seoul (KR)
Inventor: Kim, Sungtae
416 Maetan Dong,
Paldal-Gu
Suwon-City, Kyungki-do (KR)

(74) Representative: Neill, Alastair William et al
APPLEYARD LEES
15 Clare Road
Halifax, West Yorkshire HX1 2HY (GB)

(54) Motion compensation encoding method and apparatus adaptive to motion amount

(57) A motion compensating encoding apparatus adaptive to a motion amount adaptively generates motion-compensated pixel values for performing differential pulse code modulation of pixel values of a current image even when a current image motion amount to be motion-compensated with respect to a reference image is beyond a predetermined motion amount. The motion compensation encoding apparatus includes a global motion estimator (53) for generating a global motion vector representing spatial position difference between the reference image according to the pixel values stored in a first memory (17) and the current image according to the pixel values stored in a second memory (56), motion-compensating the reference image on the basis of the generated global motion vector and storing the pixel values of the motion-compensated reference image, a local motion estimator (54) for generating a local motion vector according to comparison of the pixel values between a current video block which is formed by the pixel values supplied from the second memory (56), and which has a size smaller than the current image and a search area formed by part of the pixel values stored in the global motion estimator (53), a motion compensator (55) for receiving the local motion vector from the local motion estimator (54) and generating motion-compensated pixel values by using the pixel values stored in the global motion estimator (53) and the local motion vector, and a unit (31) for generating a difference value between the respective pixel values of each image secondly output from the second memory (56) and the corresponding motion-compensated pixel values output from the motion compensator (55).

FIG. 3



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The present invention relates to a motion compensation encoding method which is adaptive to an amount of motion and the apparatus thereof, and more particularly, though not exclusively, to a motion compensation encoding method for use in a differential pulse encoded video signal capable of adaptively performing a motion compensation encoding operation even when an amount of motion between images is beyond a predetermined amount of motion.

In a recent system, a video signal is usually encoded into digital data and then processed to improve a quality of the picture. However, when the video signal is encoded into the digital data, an amount of data becomes considerably large. To solve such a problem, a conventional video encoding system utilizes a transformation encoding method, a differential pulse code modulation (DPCM) method, a vector quantization method and a variable length coding (VLC) method, thereby removing redundancy data included in a digital video signal to reduce an amount of the total data. Referring to Figure 1, a conventional motion image encoder having a well-known structure will be described below.

One frame digital video signal is reconstructed as M x N pixels. Pixel values of the reconstructed video blocks are stored in memory 10. The pixel values stored in memory 10 are applied to a motion estimator 18, a subtracter 31 and a ratio controller 20. Motion estimator 18 uses pixel values of a current image supplied from memory 10 and pixel values of a reference image stored in a frame memory 17, to estimate an amount of motion with respect to the respective video blocks of the current image. Motion estimation is performed on the basis of correlation between frames. Motion estimator 18 finds a reference video block having image information nearly identical to that of a current video block used for comparison in a search area which becomes a part of the reference image, to then generate a motion vector MV representing a spatial position difference between the current video block and the reference video block. A motion compensator 19 reads pixel values of the reference video block which is designated by motion vector MV produced by motion estimator 18, from frame memory 17. The read pixel values are output to subtracter 31. Subtracter 31 subtracts a corresponding pixel value applied from motion compensator 19 from a pixel value supplied from memory 10 for a differential pulse code modulation and outputs a differential pixel value obtained by substraction to a transformer 11. A transformer 11 transforms spatial region pixel values supplied from subtracter 31 into frequency region transform coefficient values. Transformer 11 uses one among a discrete cosine transform (DCT) method, a Walsh-Hadamard transform (WHT) method, a discrete Fourier transform (DFT) method or a discrete sine transform (DST) method, to perform a transform operation in units of a video block having M x N pixels. The transform coefficient values output from transformer 11 are quantized by a quantizer 12 to then be supplied to a variable-length coder 13 and an inverse quantizer 15. Quantizer 12 and inverse quantizer 15 quantizes and inverse-quantizes respectively the input data according to a quantization control signal Qss applied from ratio controller 20.

Since technologies in connection with quantizer 12 and inverse quantizer 15 are well known, detailed descriptions thereof will be omitted. Variable-length coder 13 variable-length-codes the input data. A buffer 14 temporarily stores the data output from variable-length coder 13 prior to being transmitted, and outputs a buffer fullness representing a storage state of buffer 14 to ratio controller 20. Ratio controller 20 generates a control signal Qss for quantization on the basis of the pixel values supplied from memory 10 and the buffer fullness applied from buffer 14. On the other hand an inverse transformer 16 performs an inverse transform of the transform coefficient values applied from inverse quantizer 15 with respect to the transform by transformer 11, to generate spatial region pixel values. An adder 32 adds pixel values applied from motion compensator 19 and pixel values applied from inverse transformer 16, to then output the result to frame memory 17. Frame memory 17 stores the pixel values applied from adder 32. The quantization control signal generated by ratio controller 20, motion vector MV generated by motion estimator 18 and output data Vc of buffer 14 are supplied to a video decoder shown in Figure 2. Switches 33 and 34 are used for reducing the difference between an image prior to being encoded by differential pulse code modulation in the motion picture encoder shown in Figure 1 and an image after decoding in the decoder shown in Figure 2.

In the motion decoder of Figure 2, variable-length decoder 21 variable-length-decodes data Vc output from buffer 14. An inverse quantizer 22 and in inverse transformer 23 perform the same function as those of inverse quantizer 15 and inverse transformer 16 of Figure 1, respectively. Motion compensator 24 reads pixel values from frame memory 25 corresponding to motion vector MV to supply the read pixel values to an adder 26. Adder 26 adds the output data of motion compensator 24 to the output data of inverse transformer 23, to output the result to a display and frame memory 25. A switch 27 is used for the same purpose as those of above switches 33 and 34.

Since the motion image encoder shown in Figure 1 uses a search area composed of the number of pixels smaller than one frame to find a reference video block having the same image information as that of a current video block, a reference video block having the same image information as that of the current video block does not exist in a given search area, in case of a fast moving picture or a whole faning picture such as sports. The

Figure 1 motion image encoder does not perform a non-intracoding operation which obtains a difference value between image frames by using differential pulse code modulation with respect to the current video block, but performs an intracoding operation. Accordingly, an amount of bits of the encoded data becomes large. Such a problem lowers a total quality of picture and heightens a probability of occurrence of an overflow in buffer 14, in a system by a predetermined data standard which uses a proper combination of an intracoding and a non-intracoding.

It is an aim of preferred embodiments of the present invention to provide a motion compensation encoding method which estimates an amount of motion with respect to a video block to be motion-compensation-encoded and is adaptive to an amount of motion for generating the motion-compensated data, in which a global motion vector representing displacement between the frames is generated by altering a motion estimation range into a whole frame in case of an image having a large amount of motion between frames, and using data of the frame motion-compensated by the generated global motion vector.

It is another aim of preferred embodiments of the present invention to provide an apparatus embodying the aforementioned method.

It is still another aim of preferred embodiments of the present invention to provide a motion compensation encoding apparatus which is adaptive to an amount of motion for generating motion-compensated data by generating a reference image which is obtained by compensating spatial position difference between an image to be motion-compensated and an image which becomes a reference of motion compensation.

According to a first aspect of the present invention, there is provided a motion compensation encoding apparatus for use in an image encoder for performing differential pulse code modulation by using pixel values of a current image and motion-compensated pixel values, the motion compensation encoder comprising:

a first memory for storing pixel values of a reference image;

a second memory for storing pixel values with respect to a plurality of images, and repetitively outputting the stored pixel values of each image one-frame by one-frame at least twice;

global motion estimation means for generating a global motion vector representing spatial position difference between the reference image according to the pixel values stored in the first memory and the current image according to the pixel values stored in the second memory, motion-compensating the reference image on the basis of the generated global motion vector and storing the pixel values of the motion-compensated reference image;

local motion estimation means for generating a local motion vector according to comparison of the pixel values between a current video block which is formed by the pixel values supplied from the second memory, and which has a size smaller than the current image and a search area formed by part of the pixel values stored in the global motion estimation means;

motion compensation means for receiving the local motion vector from the local motion estimation means and generating motion-compensated pixel values by using the pixel values stored in the global motion estimation means and the local motion vector; and

means for generating a difference value between the respective pixel values of each image secondly output from the second memory and the corresponding motion-compensated pixel values output from the motion compensation means.

Suitably, said global motion estimator generates said local motion vector on the basis of a mean absolute error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement within the motion estimation range and the reference image.

Suitably, said global motion estimator generates said local motion vector on the basis of a mean square error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement within the motion estimation range and the reference image.

According to a second aspect of the present invention, there is provided a motion compensation encoding apparatus for use in an image encoder for performing differential pulse code modulation by using pixel values of a current image and motion-compensated pixel values, the motion compensation encoder comprising:

a first memory for storing pixel values of a reference image;

a second memory for storing pixel values with respect to a plurality of images, outputting the stored pixel values of each image one-frame by one-frame, and outputting again the pixel values of each image output one-frame by one-frame once or twice more on the basis of a first control signal;

motion discrimination means, coupled to receive the firstly output one-frame pixel values among the duplicate pixel values of the same image output from the second memory, for discriminating whether an amount of motion of the current image according to the pixel values supplied from the second memory with respect to the reference image according to the pixel values stored in the first memory, is beyond a predetermined amount of motion, and generating first and second control signals according to the discrimination result;

global motion estimation means for generating a global motion vector representing spatial position dif-

ference between the reference image according to the pixel values stored in the first memory and the current image according to the pixel values stored in the second memory, and storing the pixel values of the motion-compensated reference image on the basis of the generated global motion vector;

local motion estimation means for discriminating whether the motion-compensated reference image is stored in the global motion estimation means, and generating one of a first local motion vector according to comparison of the pixel values between a current video block which is formed by the pixel values supplied from the second memory, and which has a size smaller than the current image and a first search area formed by part of the pixel values stored in the first memory, and a second local motion vector according to comparison of the pixel values between the current video block and a second search area formed by part of the pixel values stored in the global motion estimation means, on the basis of the discrimination result;

switching means for outputting the pixel values supplied from the second memory to the local motion estimation means if the second control signal generated int he motion discrimination means represents that the current image motion amount is not beyond the predetermined motion amount, outputting one-frame pixel values among the pixel values oft eh same image supplied from the second memory, if the second control signal represents that the current image motion amount is beyond the predetermined motion amount, and outputting the following one-frame pixel values to the local motion estimation means;

motion compensation means for generating motion-compensated pixel values by using the pixel values stored in the first memory and the first local motion vector if the first local motion vector is applied from the local motion estimation means, and generating motion-compensated pixel values stored in the global motion estimation means and the second local motion vector, if the second local motion vector is applied from the local motion estimation means; and

means for generating a difference value between the respective pixel values of each image output from the second memory and the corresponding motion-compensated pixel values output from the motion compensation means.

Suitably, said second memory outputs the pixel values of the current image one-frame by one-frame twice if the first control signal represents that the current image motion amount is beyond the predetermined motion amount, while said second memory outputs the pixel values of the current image of only one frame if the first control signal represents that the former is not beyond the latter.

Suitably, said motion discriminator generates the first control signal according to a result whether the first reference video block having the same image information as that of the current video block exists in the first search area corresponding to the current video block.

Suitably, said motion discriminator discriminates whether the first reference video block having the same image information with respect to a plurality of the current video block exists in the current image.

Suitably, said global motion estimator generates said first local motion vector on the basis of a mean absolute error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement within the motion estimation range and the reference image.

Suitably, said global motion estimator generates said first local motion vector on the basis of a mean square error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement within the motion estimation range and the reference image.

Suitably, said local motion estimator generates said first local motion vector if the motion-compensated reference image is not stored in said global motion estimator, while the former generates said second local motion vector if the motion-compensated reference image is stored in said latter.

According to a third aspect of the present invention, there is provided a motion compensation encoding method for use in an image encoder for performing differential pulse code modulation by using pixel values of a current image and motion-compensated pixel values, the motion compensation encoding method comprising the steps of:

a) storing pixel values of a reference image for motion compensation;

b) storing pixel values of the current image;

c) discriminating whether an amount of motion of the current image to be motion-compensated is beyond a predetermined amount of motion on the basis of all the pixel values stored in steps a) and b);

d) generating a global motion vector representing spatial position difference of the current image of the pixel values stored in step b) with respect to the reference image of the pixel values stored in step a), if a discrimination result of step c) represents that the current image motion amount is beyond the predetermined motion amount;

e) motion-compensating the reference image corresponding to the pixel value stored in step a) to store the pixel values of the motion-compensated reference image;

f) generating a second local motion vector on the basis of comparison of pixel values between a first video block and a second search area formed by part of the pixel values stored in step e);

g) generating motion-compensated pixel values by using the second local motion vector generated in step f) and the corresponding pixel values stored in step e); and

h) generating a difference value between the respective pixel values of the current image stored in step b) and the corresponding pixel values of the motion-compensated reference image generated in step g).

Suitably, said method further comprises the steps of:

i) generating a first local motion vector on the basis of comparison of the pixel values between the first video block which is formed by the pixel values stored in step b) and having a smaller size than that of the current image and a first search area formed by a part of the pixel values stored in step a);

j) generating the motion-compensated pixel values using the first local motion vector generated in step i) and the corresponding pixel values stored in step a); and

k) generating a difference value between the respective pixel values of the current image stored in step b) and the corresponding pixel values of the motion-compensated reference image generated in step j),

wherein a discrimination result of step c) represents that the current image motion amount is not beyond the predetermined motion amount.

Suitably, said step c) comprises the sub-steps of:

c1) forming the first search area for motion estimation of the current video block, and including the current video block having a part of the current image pixel values and a part of the pixel values stored in step a);

c2) discriminating whether the reference video block having the same image information as that of the current video block exists in the first search area on the basis of comparison of the image information between the current video block pixel values formed in sub-step cl) and the corresponding blocks which exist in the first search area and having the same number of pixels as that of the current video block; and

discriminating whether the current image motion amount is beyond the predetermined motion amount on the basis of the discrimination result of sub-step c2).

Suitably, said sub-step c2) further comprises the sub-step of discriminating whether the first reference video block having the same image information with respect to a plurality of the current video blocks exists in the current image.

Suitably, said step d) further comprises the sub-step of d1) generating the global motion vector on the basis of a mean absolute error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement of the current image within the predetermined motion estimation range and the reference image.

Suitably, sub-step d1) comprises the sub-step of da1) calculating the mean absolute error value of the pixel difference values between one current image by movement using the following equation and the reference image,

$$MV(k,\ l) = \min \sum_{m=0}^{W} \sum_{n=0}^{H} \left| Y_{cur}(m+k, n+l) - Y_{ref}(m,n) \right| .$$

$$-x\_rang \le k \le x\_rang-1,$$

$$-y\_rang \le l \le y\_rang-1 \qquad \ldots\ \ldots\ (1).$$

in which $Y_{cur}(m, n)$ represents the $(m, n)^{th}$ pixel value in the current image, and $Y_{ref}(m, n)$ represents the $(m, n)^{th}$ pixel value in the reference image, characters W and H represent the number of horizontal and vertical pixels, respectively, and expressions x_rang and y_rang represent a movement range of the current image with respect to the reference image in the horizontal and vertical directions, respectively.

Suitably, step d) further comprises the sub-step of d2) generating the global motion vector on the basis of a mean square error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement of the current image within the predetermined motion estimation range and the reference image.

Suitably, said sub-step d2) comprises the sub-step of da2) calculating the mean square error value of the pixel difference values between one current image by movement using the following equation and the reference image,

$$MV(k,\ l) = \min \sum_{m=0}^{W} \sum_{n=0}^{H} |Y_{cur}(m+k, n+l) - Y_{ref}(m,n)|^2.$$

$$-x\_rang \le k \le x\_rang-1,$$
$$-y\_rang \le l \le y\_rang-1 \quad \ldots\ \ldots \quad (2).$$

in which $Y_{cur}(m, n)$ represents the $(m, n)^{th}$ pixel value in the current image, and $Y_{ref}(m, n)$ represents the $(m, n)^{th}$ pixel value in the reference image, characters W and H represent the number of horizontal and vertical pixels, respectively, and expressions x_rang and y_rang represent a movement range of the current image with respect to the reference image in the horizontal and vertical directions, respectively.

Preferred embodiments of the present invention are described, by way of example only, with reference to the drawings, wherein:

Figure 1 is a block diagram showing a conventional image encoding system.

Figure 2 is a block diagram showing a conventional image decoding system.

Figure 3 is a block diagram showing a motion compensating encoding apparatus according to a preferred embodiment of the present invention.

Figures 4A and 4B show a motion compensation encoding method which is adaptive to an amount of motion according to the present invention.

A preferred embodiment of the present invention will be described below in more detail with reference to the accompanying drawings Figures 3, 4A and 4B.

Figure 3 shows a motion compensation encoder according to a preferred embodiment of the present invention. In Figure 3, the like elements to Figure 1 use the like reference numerals thereto and the detailed description thereof will be omitted.

A construction and operation of the Figure 3 apparatus will be described below in connection with the present invention.

A memory 56 stores pixel values of a plurality of images. Memory 56 outputs the pixel values of a previous image among the stored pixel values to a ratio controller 20 and a subtracter 31, and outputs the pixel values of a current image to motion discriminator 51. Subtracter 31 subtracts the corresponding pixel values supplied from motion compensator 55 from the respective pixel values of the previous image supplied from memory 31 and outputs a difference value to a transformer 11.

On the other hand, motion estimator 51 receives the pixel values of the reference image stored in a frame memory 17 if the pixel values of the current image is supplied from memory 56 and discriminates an amount of motion of the current image with respect to the reference image. To discriminate the amount of motion of the current image with respect to the reference image, motion discriminator 51 discriminates whether a first reference video block having the same image information as that of a current video block which becomes a part of the current image exists in a first search area with respect to one or more current video blocks. Motion discriminator 51 generates a first control signal CTL1 representing whether motion estimation of the current image is possible using the pixel values of the reference image on the basis of the detection result. Motion discriminator 51 generates a second control signal CTL2 on the basis of the above discrimination result. If first control signal CTL1 represents that the motion estimation of the current image is possible using the pixel values of the reference image, memory 56 supplies the pixel values of the current image to a switch 52. Memory 56 supplies the pixel values of the current image again to a subtracter 31 after all the pixel values of the current image are supplied to switch 52. Switch 52 supplies the pixel values of the current image supplied via an input end C from memory 56 to a local motion estimator 54 via a first output end A, according to the applied second control signal CTL2. Local motion estimator 54 discriminates whether the pixel values of the compensated reference image are stored in global motion estimator 53. If the pixel values of the compensated reference image are not stored in global motion estimator 53 as a discrimination result, local motion estimator 54 uses the pixel values of the reference image stored in frame memory 17 and the pixel values of the current image applied via switch 52, and generates a first local motion vector LMV1 with respect to a current video block.

The generation of the first local motion vector LMV1 will be described below with reference to Figure 4A. In Figure 4A, first local motion vector LMV1 is determined on the basis of the current video block within the current image and the first search area within the reference image. Here, the first search area has a smaller number of pixels than that of the reference image, and has a position on an image corresponding to the current video block. In Figure 4A, the current video block is represented as a hatched rectangular shape, and the first

reference video block having the same image information as that of the current video block is represented as a hatched rectangular shape. Local motion estimator 54 compares a corresponding block having the same number of pixels as that of the current video block and which is located on the left-upper end in the first search area and all blocks which are obtained by moving the corresponding block one-pixel by one-pixel to the right direction and/or to the down direction with the current video block. A method used for comparison is a well-known mean absolute error (MAE) method or mean square error (MSE) method. If the first reference video block having the least difference value from the current video block is determined by comparison of the pixel values of the MAE or MSE, local motion estimator 54 generates a first local motion vector LMV1 representing spatial position difference between the first reference video block and the current video block. First local motion vector LMV1 is produced with respect to the respective current video blocks and the produced first motion vector LMV1 is supplied to motion compensator 55.

Motion compensator 55 discriminates that the pixel values of the compensated reference image are not stored in global motion estimator 53, if first motion vector LMV1 is applied from motion estimator 54. Based on such discrimination, motion compensator 55 generates the motion-compensated pixel values according to the pixel values of the reference image stored in frame memory 17 and the first local motion vector LMV1 generated in motion estimator 54. Subtracter 31 subtracts the corresponding pixel values supplied from motion compensator 55 from the respective pixel values of the current image supplied from memory 56 and outputs the difference value obtained by subtraction to transformer 11. The pixel values output from motion compensator 55 are also supplied to an adder 32, by which is added to the data output from inverse transformer 16. The pixel values obtained by adder 32 are stored in frame memory 17 and used as the pixel values of the reference image for motion-compensating the following image.

If first control signal CTL1 generated in motion discriminator 51 represents that motion estimation of the current image is not possible using the pixel values of the reference image, memory 56 repetitively supplies the pixel values of the current image one-frame by one-frame twice to switch 52. After memory 56 repetitively supplies the pixel values of the current image twice to switch 52, the pixel values of the current image are also supplied to subtracter 31. Switch 52 supplies the pixel values of firstly input one-frame current image among the pixel values of the two-frame current image supplied via input end C from memory 56 according to the applied second control signal CTL2, via a second output end B to local motion estimator 54. Then, switch 52 supplies the pixel values of the secondly applied current image via first output end A to local motion estimator 54. Local motion estimator 54 does not generate a local motion vector during the time when the pixel values of the current image are not supplied via switch 52. Subtracter 31 does not operate as well since the pixel values of the current image from memory 56 and the motion-compensated pixel values from motion compensator 55 are not supplied thereto.

Global motion estimator 53 generates a global motion vector GMV representing spatial position difference of the current image with respect to the reference image by using all the pixel values of the current image applied from second output end B of switch 52 and all the pixel values of the reference image stored in frame memory 17. Global motion estimator 53 uses one among the following equations (1) according to the MAE method or following equation (2) according to the MSE method, to generate global motion vector GMV. The relationship between the reference image and the compensated reference image is conceptually shown in Figure 4B. As can be seen from Figure 4B, global motion vector GMV represents the spatial position difference of the current image with respect to the reference image.

$$MV(k,\ l) = \min \sum_{m=0}^{W} \sum_{n=0}^{H} |Y_{cur}(m+k, n+l) - Y_{ref}(m,n)|.$$

$$-x\_rang \leq k \leq x\_rang-1,$$
$$-y\_rang \leq l \leq y\_rang-1 \qquad \ldots\ \ldots\ (1).$$

$$MV(k,\ l) = \min \sum_{m=0}^{W} \sum_{n=0}^{H} |Y_{cur}(m+k, n+l) - Y_{ref}(m,n)|^2.$$

$$-x\_rang \le k \le x\_rang-1,$$
$$-y\_rang \le l \le y\_rang-1 \qquad \ldots\ \ldots \ (2).$$

Here, $Y_{cur}(m, n)$ represents the $(m, n)^{th}$ pixel value in the current image, and $Y_{ref}(m, n)$ represents the $(m, n)^{th}$ pixel value in the reference image. Characters W and H represent the number of horizontal and vertical pixels, respectively. Expression x_rang and y_rang represent a movement range of the current image with respect to the reference image in the horizontal and vertical directions, respectively. That is, the current image can have a position with respect to the reference image within the range from -x_rang to x_range-1 of the reference image in the horizontal direction. This is also same as that in the vertical direction. As shown in Figure 4B, global motion estimator 53 receives and stores the pixel values of the compensated reference image having a reference position moved from frame memory 17, by moving a position of the reference image by global motion vector GMV. Actually, in case of pixels to be added to a newly compensated reference frame by movement of the reference frame among the pixel values of the compensated reference frame stored in global motion estimator 53, all pixel values are established into any one of the same values. Such a value can be set to a specific value of "0" or "255" in case of a pixel value representing 256 gradation.

After global motion vector GMV and the compensated reference image have been completely determined by global motion estimator 53, the pixel values of the current image supplied from memory 56 are supplied via switch 52 to local motion estimator 54. Local motion estimator 54 determines whether the pixel values of the compensated reference image are stored in global motion estimator 53, if the pixel values of the current image are applied via first output end A of switch 52. If global motion estimator 53 stores the pixel values of the compensated reference image according to the discrimination result, local motion estimator 54 uses the pixel values of the compensated reference image stored in global motion estimator 53 and the pixel values of the current image applied via switch 52, to generate a second local motion vector LMV2 with respect to the current video block. Since a generation process of second local motion vector LMV2 in local motion estimator 54 is similar to that of motion estimator 18 which determines the first reference video block with respect to the current video block by using the pixel values stored in frame memory 17, the generation process thereof will be omitted.

Local motion estimator 54 compares the pixel values of the current video block with the pixel values in a second search area of the compensated reference frame, and determines a second reference video block in the second search area having the same image information as that of the current video block. Here, the second search area has a position which is moved by a value of global motion vector GMV from the first search area as shown in Figure 4B, and has a position corresponding to the current video block used for comparison within the compensated reference image as well. Local motion estimator 54 generates second local motion vector LMV2 representing spatial position difference between the current video block and the second reference video block, if the second reference video block is determined. The generated second local motion vector LMV2 is supplied to motion compensator 55.

Motion compensator 55 uses the pixel values of the compensated reference image stored in global motion estimator 53 and the second local motion vector LMV2 to obtain the motion-compensated pixel values with respect to the current video block if the second local motion vector LMV2 is applied thereto, and then outputs the obtained pixel values to subtracter 31 and adder 32. Subtracter 31 subtracts the motion-compensated pixel values supplied from motion compensator 55 from the pixel values of the current image supplied from memory 56. Thereafter, since operation of the Figure 3 apparatus is the same as the motion compensation operation using the first local motion vector LMVl, the detailed description thereof will be omitted. The global motion vector GMV and local motion vector LMV1 or LMV2 generated in the Figure 3 apparatus are transmitted to a decoder (not shown) for decoding the motion-compensated encoded image.

In the case of the above-described embodiment, the apparatus of Figure 3 operates on the basis of the control signals according to the discrimination of motion discriminator 51. It is, however, possible to provide other variations which are obtained by removing motion discriminator 51 and switch 52. The modified embodiment will be briefly described below referring to Figure 3.

If memory 56 outputs the pixel values of the current image, global motion estimator 53 generates a global motion vector of the current image with respect to the reference image in the same manner as that described

referring to Figure 3. Global motion estimator 53 uses the generated global motion vector, motion-compensates the reference image, and stores the pixel values of the motion-compensated reference image.

Motion estimator 54 generates a local motion vector on the basis of the motion-compensated reference image stored in global motion estimator 53 and the pixel values of the current image applied from memory 56. Motion compensator 54 uses the local motion vector and the pixel values stored in global motion estimator 53, to generate the motion-compensated pixel values. Thus, motion compensator 54 can generate the motion-compensated pixel values properly as well when an amount of motion of the current image with respect to the reference image is beyond a predetermined motion amount.

As described above, the motion compensation encoder adaptive to an amount of motion according to the present invention can determine a motion vector with respect to the respective video blocks in the current image, even when motion vectors with respect to the respective video blocks in the current image cannot determine using the search area determined in the reference image. Thus, a problem of increasing an amount of the transmission data occurring in the conventional motion compensation encoding system which performs an intracoding operation because of no determination of the motion vector with respect to an image having a large amount of motion, can be solved.

While only certain embodiments of the invention have been specifically described herein, it will be apparent that numerous modifications may be made thereto without departing from the spirit and scope of the invention.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A motion compensation encoding apparatus for use in an image encoder for performing differential pulse code modulation by using pixel values of a current image and motion-compensated pixel values, said motion compensation encoder comprising:

a first memory (17) for storing pixel values of a reference image;

a second memory (56) for storing pixel values with respect to a plurality of images, and repetitively outputting the stored pixel values of each image one-frame by one-frame at least twice;

global motion estimation means (53) for generating a global motion vector representing spatial position difference between the reference image according to the pixel values stored in the first memory (17) and the current image according to the pixel values stored in the second memory (56), motion-compensating the reference image on the basis of the generated global motion vector and storing the pixel values of the motion-compensated reference image;

local motion estimation means (54) for generating a local motion vector according to comparison of the pixel values between a current video block which is formed by the pixel values supplied from the second memory (56), and which has a size smaller than the current image and a search area formed by part of the pixel values stored in the global motion estimation means (53);

motion compensation means (55) for receiving the local motion vector from the local motion estimation means (54) and generating motion-compensated pixel values by using the pixel values stored in the global motion estimation means (53) and the local motion vector; and

means (31) for generating a difference value between the respective pixel values of each image secondly output from the second memory (56) and the corresponding motion-compensated pixel values output from the motion compensation means (55).

2. A motion compensation encoding apparatus according to claim 1, wherein said global motion estimator (53) generates said local motion vector on the basis of a mean absolute error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement within the motion estimation range and the reference image.

3. A motion compensation encoding apparatus according to claim 1, wherein said global motion estimator (53) generates said local motion vector on the basis of a mean square error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement within the motion estimation range and the reference image.

4. A motion compensation encoding apparatus for use in an image encoder for performing differential pulse code modulation by using pixel values of a current image and motion-compensated pixel values, said motion compensation encoder comprising:

a first memory (17) for storing pixel values of a reference image;

a second memory (56) for storing pixel values with respect to a plurality of images, outputting the stored pixel values of each image one-frame by one-frame, and outputting again the pixel values of each image output one-frame by one-frame once or twice more on the basis of a first control signal;

motion discrimination means (51), coupled to receive the firstly output one-frame pixel values among the duplicate pixel values of the same image output from the second memory (56), for discriminating whether an amount of motion of the current image according to the pixel values supplied from the second memory (56) with respect to the reference image according to the pixel values stored in the first memory (17), is beyond a predetermined amount of motion, and generating first and second control signals according to the discrimination result;

global motion estimation means (53) for generating a global motion vector representing spatial position difference between the reference image according to the pixel values stored in the first memory (17) and the current image according to the pixel values stored in the second memory (56), and storing the pixel values of the motion-compensated reference image on the basis of the generated global motion vector;

local motion estimation means (54) for discriminating whether the motion-compensated reference image is stored in the global motion estimation means (53), and generating one of a first local motion vector according to comparison of the pixel values between a current video block which is formed by the pixel values supplied from the second memory (56), and which has a size smaller than the current image and a first search area formed by part of the pixel values stored in the first memory (17), and a second local motion vector according to comparison of the pixel values between the current video block and a second search area formed by part of the pixel values stored in the global motion estimation means (53), on the basis of the discrimination result;

switching means (52) for outputting the pixel values supplied from the second memory (56) to the local motion estimation means (54) if the second control signal generated in the motion discrimination means (51) represents that the current image motion amount is not beyond the predetermined motion amount, outputting one-frame pixel values among the pixel values of the same image supplied from the second memory (56), if the second control signal represents that the current image motion amount is beyond the predetermined motion amount, and outputting the following one-frame pixel values to the local motion estimation means (54);

motion compensation means (55) for generating motion-compensated pixel values by using the pixel values stored in the first memory (17) and the first local motion vector if the first local motion vector is applied from the local motion estimation means (54), and generating motion-compensated pixel values stored in the global motion estimation means (53) and the second local motion vector, if the second local motion vector is applied from the local motion estimation means (54); and

means (31) for generating a difference value between the respective pixel values of each image output from the second memory (56) and the corresponding motion-compensated pixel values output from the motion compensation means (55).

5. A motion compensation encoding apparatus according to claim 4, wherein said second memory (56) outputs the pixel values of the current image one-frame by one-frame twice if the first control signal represents that the current image motion amount is beyond the predetermined motion amount, while said second memory (56) outputs the pixel values of the current image of only one frame if the first control signal represents that the former is not beyond the latter.

6. A motion compensation encoding apparatus according to claim 4 or claim 5, wherein said motion discriminator generates the first control signal according to a result whether the first reference video block having the same image information as that of the current video block exists in the first search area corresponding to the current video block.

7. A motion compensation encoding apparatus according to any of claims 4 to 6, wherein said motion discriminator discriminates whether the first reference video block having the same image information with respect to a plurality of the current video block exists in the current image.

8. A motion compensation encoding apparatus according to any of claims 4 to 7, wherein said global motion estimator (53) generates said first local motion vector on the basis of a mean absolute error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement within the motion estimation range and the reference image.

9. A motion compensation encoding apparatus according to any of claims 4 to 7, wherein said global motion estimator (53) generates said first local motion vector on the basis of a mean square error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement within the motion estimation range and the reference image.

10. A motion compensation encoding apparatus according to any of claims 4 to 9, wherein said local motion estimator (54) generates said first local motion vector if the motion-compensated reference image is not stored in said global motion estimator (53), while the former generates said second local motion vector if the motion-compensated reference image is stored in said latter.

11. A motion compensation encoding method for use in an image encoder for performing differential pulse code modulation by using pixel values of a current image and motion compensated pixel values, said motion compensation encoding method comprising the steps of:
a) storing pixel values of a reference image for motion compensation;
b) storing pixel values of the current image;
c) discriminating whether an amount of motion of the current image to be motion-compensated is beyond a predetermined amount of motion on the basis of all the pixel values stored in steps a) and b);
d) generating a global motion vector representing spatial position difference of the current image of the pixel values stored in step b) with respect to the reference image of the pixel values stored in step a), if a discrimination result of step c) represents that the current image motion amount is beyond the predetermined motion amount;
e) motion compensating the reference image corresponding to the pixel values stored in step a) to store the pixel values of the motion-compensated reference image;
f) generating a second local motion vector on the basis of comparison of pixel values between a first video block and a second search area formed by part of the pixel values stored in step e);
g) generating motion-compensated pixel values by using the second local motion vector generated in step f) and the corresponding pixel values stored in step e); and
h) generating a difference value between the respective pixel values of the current image stored in step b) and the corresponding pixel values of the motion-compensated reference image generated in step g).

12. A motion compensation encoding method according to claim 11, further comprising the steps of:
i) generating a first local motion vector on the basis of comparison of the pixel values between the first video block which is formed by the pixel values stored in step b) and having a smaller size than that of the current image and a first search area formed by a part of the pixel values stored in step a);
j) generating the motion-compensated pixel values using the first local motion vector generated in step i) and the corresponding pixel values stored in step a); and
k) generating a difference value between the respective pixel values of the current image stored in step b) and the corresponding pixel values of the motion-compensated reference image generated in step j),
wherein a discrimination result of step c) represents that the current image motion amount is not beyond the predetermined motion amount.

13. The motion compensation encoding method according to claim 11 or claim 12, wherein said step c) comprises the sub-steps of:

c1) forming the first search area for motion estimation of the current video block, and including the current video block having a part of the current image pixel values and a part of the pixel values stored in step a);

c2) discriminating whether the reference video block having the same image information as that of the current video block exists in the first search area on the basis of comparison of the image information between the current video block pixel values formed in sub-step cl) and the corresponding blocks which exist in the first search area and having the same number of pixels as that of the current video block; and

discriminating whether the current image motion amount is beyond the predetermined motion amount on the basis of the discrimination result of sub-step c2).

14. A motion compensation encoding method according to claim 13, wherein said sub-step c2) further comprises the sub-step of discriminating whether the first reference video block having the same image information with respect to a plurality of the current video blocks exists in the current image.

15. A motion compensation encoding method according to any of claims 11 to 14, wherein said step d) further comprises the sub-step of dl) generating the global motion vector o the basis of a mean absolute error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement of the current image within the predetermined motion estimation range and the reference image.

16. A motion compensation encoding method according to claim 15, wherein said sub-step dl) comprises the sub-step of dal) calculating the mean absolute error value of the pixel difference values between one current image by movement using the following equation and the reference image,

$$MV(k,\ l) = \min \sum_{m=0}^{W} \sum_{n=0}^{H} |Y_{cur}(m+k, n+l) - Y_{ref}(m,n)|.$$

$$-x\_rang \le k \le x\_rang-1,$$
$$-y\_rang \le l \le y\_rang-1$$

in which $Y_{cur}(m, n)$ represents the (m, n)th pixel value in the current image, and $Y_{ref}(m, n)$ represents the (m, n)th pixel value in the reference image, characters W and H represent the number of horizontal and vertical pixels, respectively, and expressions x_rang and y_rang represent a movement range of the current image with respect to the reference image in the horizontal and vertical directions, respectively.

17. A motion compensation encoding method according to any of claims 11 to 16, wherein step d) further comprises the sub-step of d2) generating the global motion vector on the basis of a mean square error value according to pixel difference values between a plurality of a respectively moved current image obtained by movement of the current image within the predetermined motion estimation range and the reference image.

18. A motion compensation encoding method according to claim 17, wherein said sub-step d2) comprises the sub-step of da2) calculating the mean square error value of the pixel difference values between one current image by movement using the following equation and the reference image,

$$MV(k,\ l) = \min \sum_{m=0}^{W} \sum_{n=0}^{H} |Y_{cur}(m+k, n+l) - Y_{ref}(m,n)|^2 .$$

$$-x\_rang \le k \le x\_rang-1,$$
$$-y\_rang \le l \le y\_rang-1$$

In which $Y_{cur}(m, n)$ represents the $(m, n)^{th}$ pixel value in the current image, and $Y_{ref}(m, n)$ represents the $(m, n)^{th}$ pixel value in the reference image, characters W and H represent the number of horizontal and vertical pixels, respectively, and expressions x_rang and y_rang represent a movement range of the current image with respect to the reference image in the horizontals and vertical directions, respectively.

FIG. 1 (PRIOR ART)

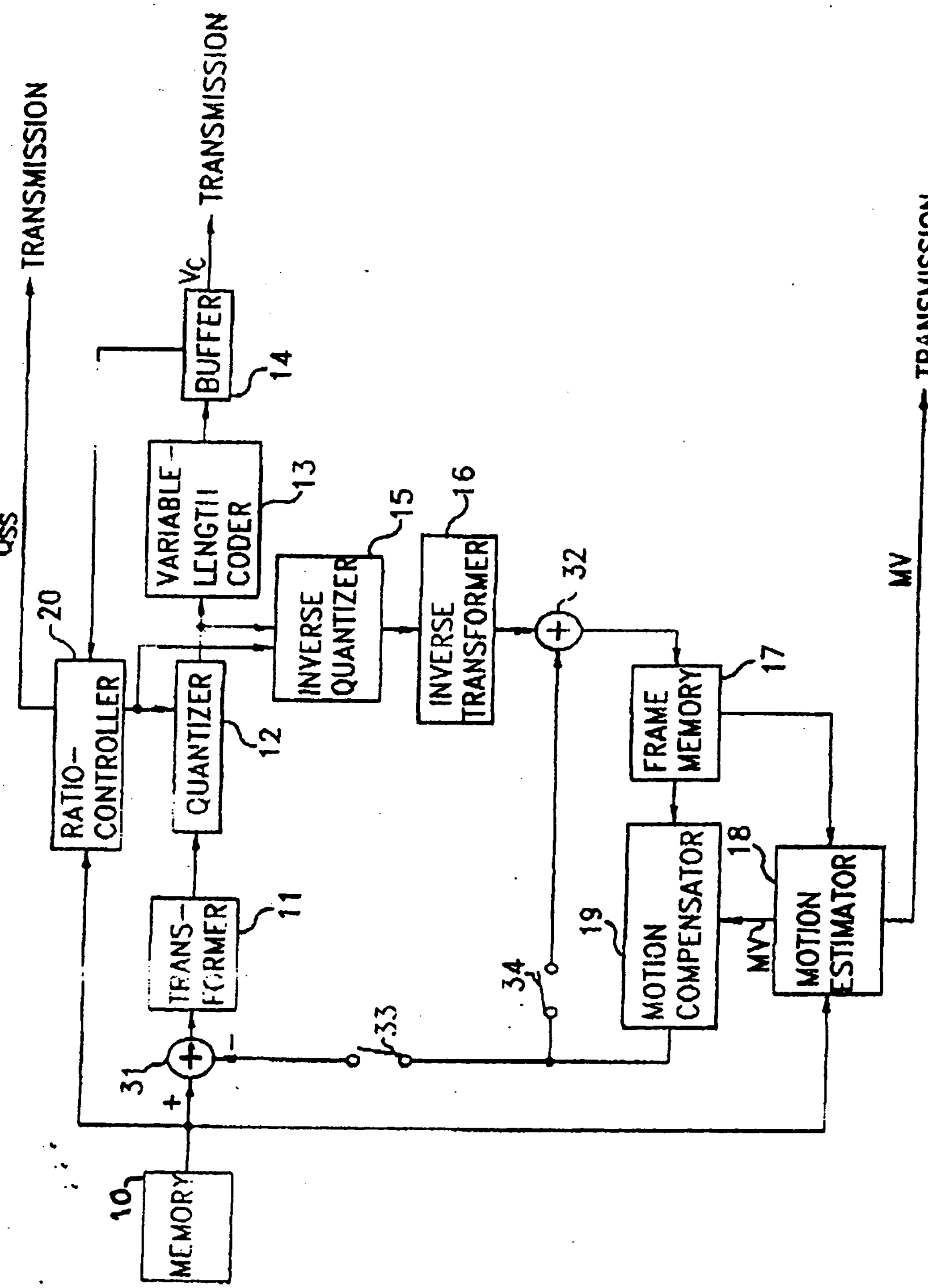


FIG. 2 (PRIOR ART)

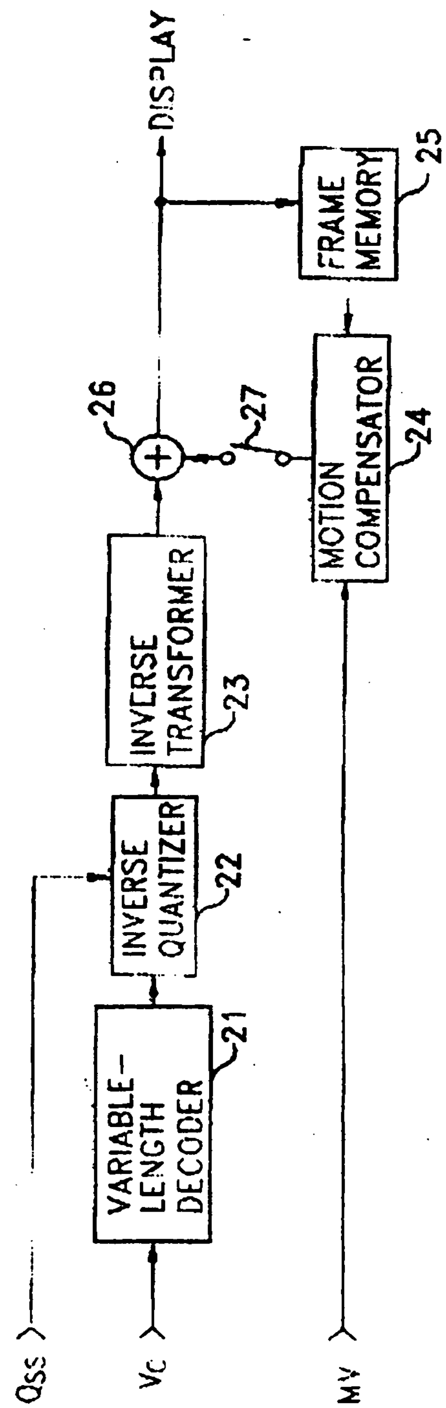


FIG. 3

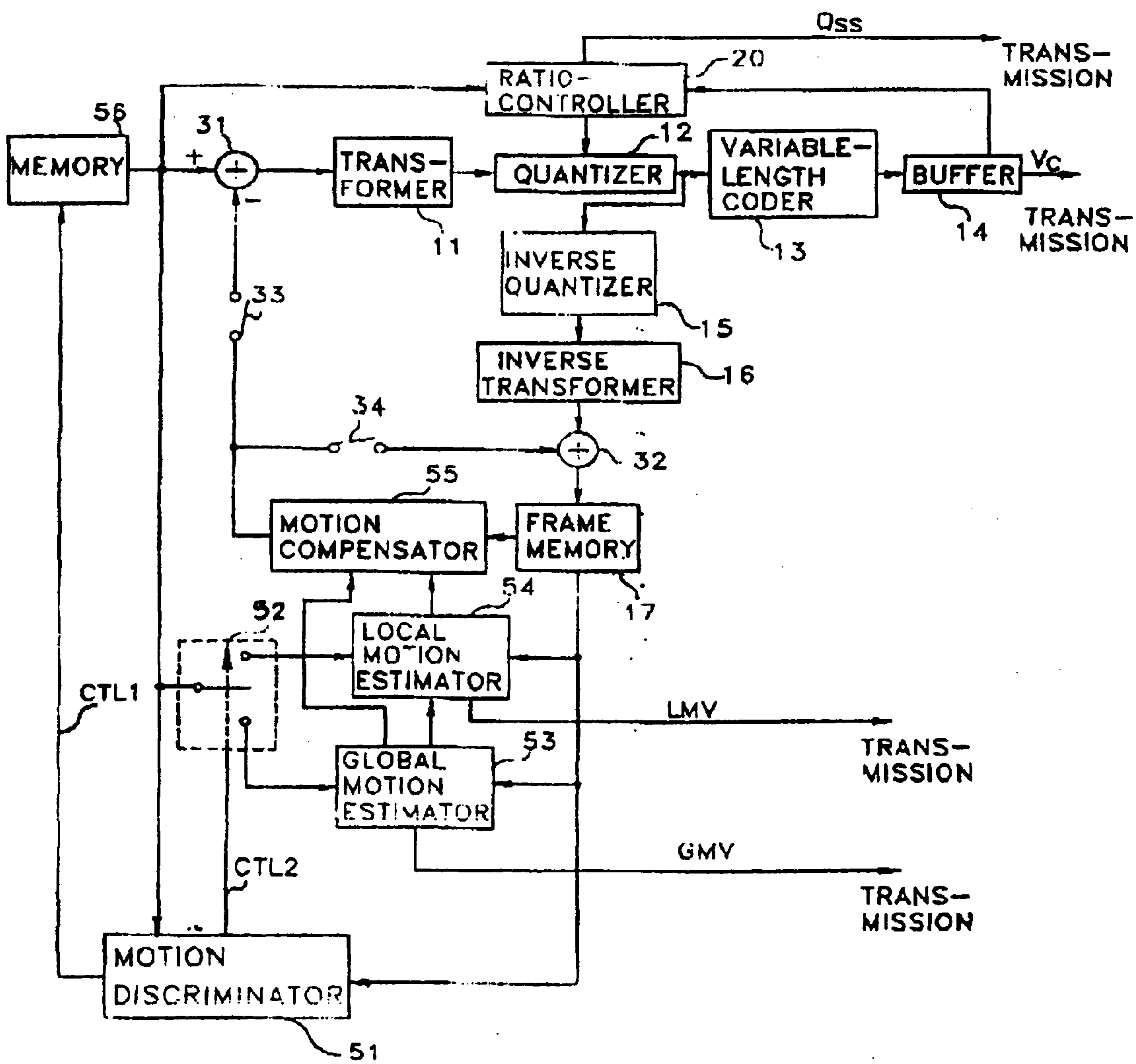

Qss
TRANS-MISSION
20
RATIO-CONTROLLER
56
MEMORY
31
+
-
TRANS-FORMER
11
12
QUANTIZER
VARIABLE-LENGTH CODER
13
BUFFER
14
Vc
TRANS-MISSION
INVERSE QUANTIZER
15
33
INVERSE TRANSFORMER
16
34
32
55
MOTION COMPENSATOR
FRAME MEMORY
17
54
52
LOCAL MOTION ESTIMATOR
CTL1
LMV
TRANS-MISSION
53
GLOBAL MOTION ESTIMATOR
GMV
TRANS-MISSION
CTL2
MOTION DISCRIMINATOR
51

FIG. 4A

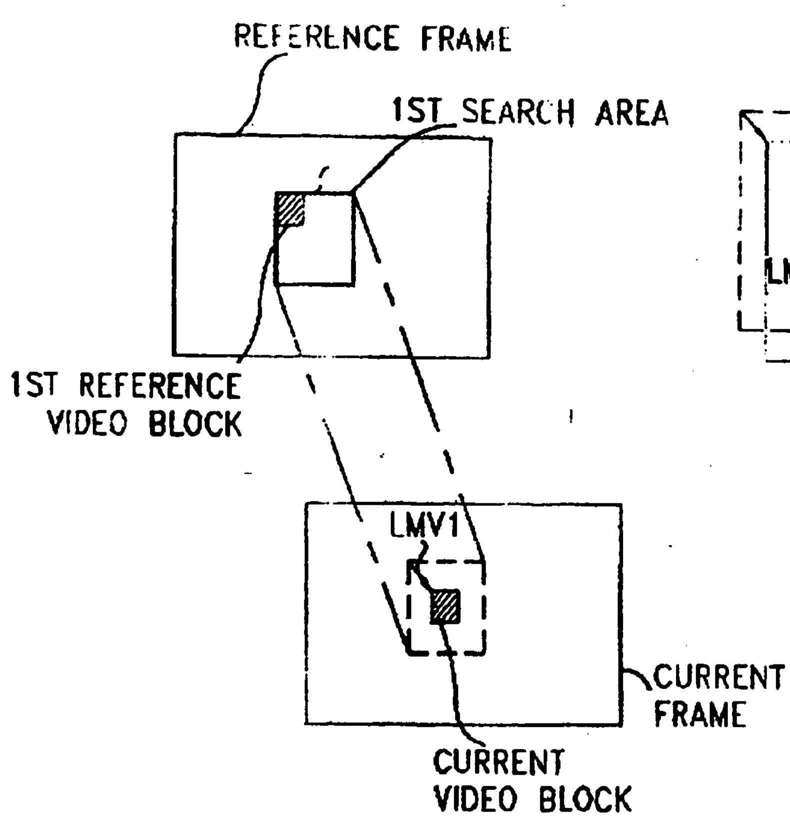
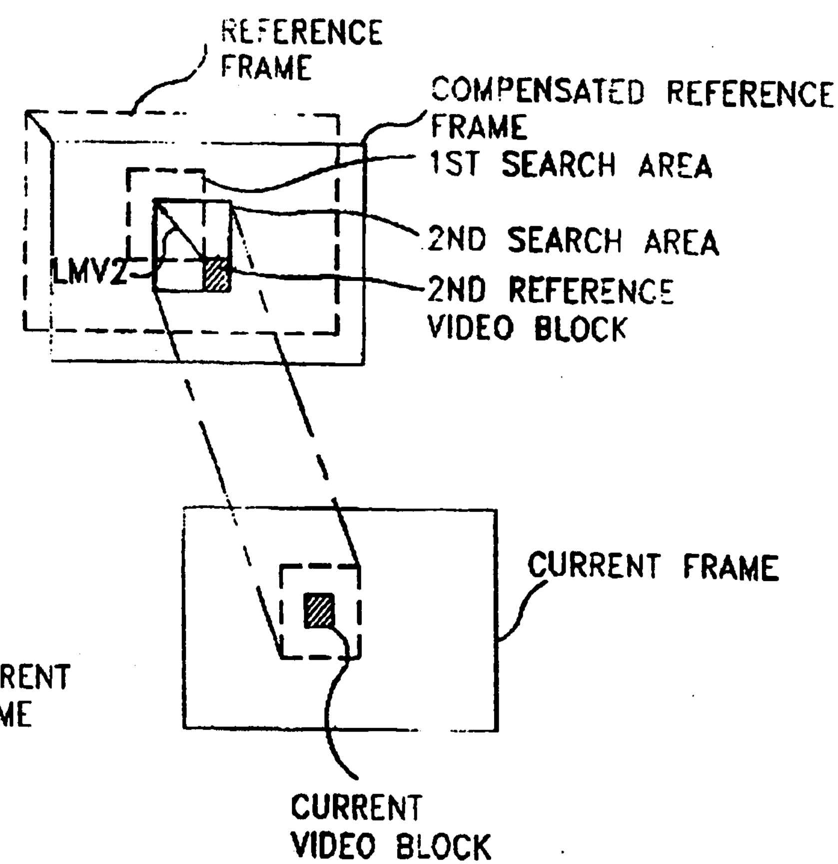

REFERENCE FRAME
1ST SEARCH AREA
1ST REFERENCE VIDEO BLOCK
LMV1
CURRENT FRAME
CURRENT VIDEO BLOCK

FIG. 4B


REFERENCE FRAME
COMPENSATED REFERENCE FRAME
1ST SEARCH AREA
2ND SEARCH AREA
2ND REFERENCE VIDEO BLOCK
LMV2
CURRENT FRAME
CURRENT VIDEO BLOCK

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 689 359 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
02.05.1997 Bulletin 1997/18

(43) Date of publication A2:
27.12.1995 Bulletin 1995/52

(21) Application number: **95304120.9**

(22) Date of filing: **14.06.1995**

(51) Int Cl.6: **H04N 7/50**, H04N 7/26, H04N 7/36

(84) Designated Contracting States:
DE FR GB

(30) Priority: **15.06.1994 KR 9413488**

(71) Applicant: **Samsung Electronics Co., Ltd.**
Suwon-city, Kyungki-do 441-370 (KR)

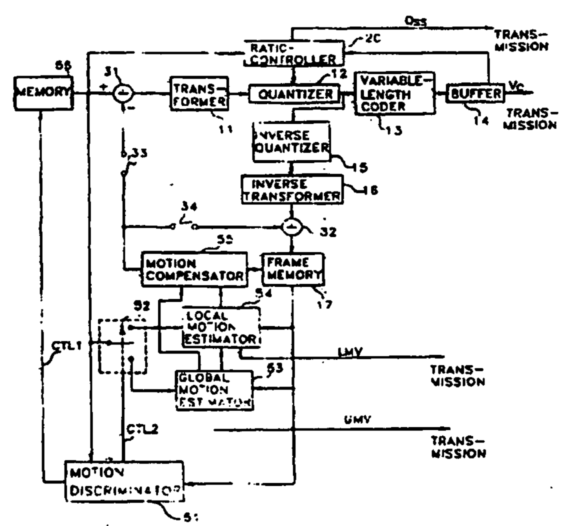
(72) Inventors:
- **Jeong, Jechang**
  Seocho-gu, Seoul (KR)
- **Kim, Sungtae**
  Suwon-City, Kyungki-do (KR)

(74) Representative: **Neill, Alastair William et al**
APPLEYARD LEES
15 Clare Road
Halifax, West Yorkshire HX1 2HY (GB)

(54) Motion compensation encoding method and apparatus adaptive to motion amount

(57) A motion compensating encoding apparatus adaptive to a motion amount adaptively generates motion-compensated pixel values for performing differential pulse code modulation of pixel values of a current image even when a current image motion amount to be motion-compensated with respect to a reference image is beyond a predetermined motion amount. The motion compensation encoding apparatus includes a global motion estimator (53) for generating a global motion vector representing spatial position difference between the reference image according to the pixel values stored in a first memory (17) and the current image according to the pixel values stored in a second memory (56), motion-compensating the reference image on the basis of the generated global motion vector and storing the pixel values of the motion-compensated reference image, a local motion estimator (54) for generating a local motion vector according to comparison of the pixel values between a current video block which is formed by the pixel values supplied from the second memory (56), and which has a size smaller than the current image and a search area formed by part of the pixel values stored in the global motion estimator (53), a motion compensator (55) for receiving the local motion vector from the local motion estimator (54) and generating motion-compensated pixel values by using the pixel values stored in the global motion estimator (53) and the local motion vector, and a unit (31) for generating a difference value between the respective pixel values of each image secondly output from the second memory (56) and the corresponding motion-compensated pixel values output from the motion compensator (55).

FIG. 3



EP 0 689 359 A3

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EUROPEAN SEARCH REPORT

Application Number
EP 95 30 4120

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	SIGNAL PROCESSING. IMAGE COMMUNICATION, vol. 3, no. 2 / 03, 1 June 1991, AMSTERDAM, NL, pages 259-274, XP000234968 ADOLPH D ET AL: "1.15 MBIT/S CODING OF VIDEO SIGNALS INCLUDING GLOBAL MOTION COMPENSATION" * page 262, left-hand column, line 25 - page 268, right-hand column, line 46 * * page 273, left-hand column, line 14 - page 274, left-hand column, line 32 * * figures 3,5-7 * ---	1,2,4, 11,13	H04N7/50 H04N7/26 H04N7/36
A	IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY, vol. 4, no. 3, 1 June 1994, NEW YORK, NY, US, pages 276-287, XP000460759 LI H ET AL: "TWO-VIEW FACIAL MOVEMENT ESTIMATION" * page 278, left-hand column, line 1 - page 282, right-hand column, line 8 * ---	1-18	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	SIGNAL PROCESSING. IMAGE COMMUNICATION, vol. 2, no. 2, 1 August 1990, AMSTERDAM, NL, pages 171-185, XP000243476 HERPEL C ET AL: "ADAPTATION AND IMPROVEMENT OF CCITT REFERENCE MODEL 8 VIDEO CODING FOR DIGITAL STORAGE MEDIA APPLICATIONS" * page 175, left-hand column, line 20 - right-hand column, line 4 * * page 178, right-hand column, line 25 - page 181, left-hand column, line 30 * * figure 4 * --- -/--	1,4-6, 11,12	H04N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 February 1997	Van der Zaal, R

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Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	WO 93 21733 A (DV SWEDEN AB ;WEISS PETER (SE); CHRISTENSSON BJOERN (SE)) 28 October 1993 * page 4, line 1 - line 32 * * page 6, line 11 - page 8, line 35 * * figures 1-3 * ---	1,4,11	
A	EP 0 419 752 A (RAI RADIOTELEVISIONE ITALIANA) 3 April 1991 * page 3, column 3, line 20 - page 4, column 6, line 43 * * figures 1,2 * -----	1-4,11	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

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THE HAGUE	27 February 1997	Van der Zaal, R

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& : member of the same patent family, corresponding document